Earth Science, 10th edition
Chapter 6: **Earthquakes and Earth's Interior**

I. Earthquakes
  A. General features
    1. Vibration of Earth produced by the rapid release of energy
    2. Associated with movements along faults
      a. Explained by the plate tectonics theory
      b. Mechanism for earthquakes was first explained by H. Reid
        1. Early 1900s
        2. Rocks "spring back"
          a. Phenomena called elastic rebound
          b. Vibrations (earthquakes) occur as rock elastically returns to its original shape
      c. Fault creep
    3. Often preceded by foreshocks
    4. Often followed by aftershocks
  B. Earthquake waves
    1. Study of earthquake waves is called seismology
    2. Earthquake recording instrument (seismograph)
      a. Records movement of Earth
      b. Record is called a seismogram
    3. Types of earthquake waves
      a. Surface waves
        1. Complex motion
        2. Slowest velocity of all waves
      b. Body waves
        1. Primary (P) waves
          a. Push-pull (compressional) motion
          b. Travel through
            1. Solids
            2. Liquids
            3. Gases
          c. Greatest velocity of all earthquake waves
        2. Secondary (S) waves
          a. "Shake" motion
          b. Travel only through solids
          c. Slower velocity than P waves
  C. Locating an earthquake
    1. Focus – the place within Earth where earthquake waves originate
    2. Epicenter
      a. Point on the surface, directly above the focus
        b. Located using the difference in the arrival times between P and S wave recordings, which are related to distance
      c. Three station recordings are needed to locate an epicenter
        1. Circle equal to the epicenter distance is drawn around each station
        2. Point where three circles intersect is the epicenter
    3. Earthquake zones are closely correlated with plate boundaries
      a. e.g., Circum-Pacific belt

b. e.g., Oceanic ridge system

D. Earthquake intensity and magnitude

1. Intensity

a. A measure of the degree of earthquake shaking at a given locale based on the amount of damage

b. Most often measured by the Modified Mercalli Intensity Scale

2. Magnitude

a. Concept introduced by Charles Richter in 1935

b. Often measured using the Richter scale

1. Based on the amplitude of the largest seismic wave

2. Each unit of Richter magnitude equates to roughly a 32-fold energy increase

3. Does not estimate adequately the size of very large earthquakes

c. Moment magnitude scale

1. Measures very large earthquakes

2. Derived from the amount of displacement that occurs along a fault zone

E. Earthquake destruction

1. Factors that determine structural damage

a. Intensity of the earthquake

b. Duration of the vibrations

c. Nature of the material upon which the structure rests

d. The design of the structure

2. Destruction from

a. Ground shaking

b. Liquefaction of the ground

1. Saturated material turns fluid

2. Underground objects may float to surface

c. Tsunami, or seismic sea waves

d. Landslides and ground subsidence

e. Fires

F. Earthquake prediction

1. Short-range – no reliable method yet devised for short-range predictions

2. Long-range forecasts

a. Premise is that earthquakes are repetitive

b. Region is given a probability of a quake

II. Earth's layered structure

A. Most of our knowledge of Earth's interior comes from the study of P and S earthquake waves

1. Travel times of P and S waves through Earth vary depending on the properties of the materials

2. S waves travel only through solids

B. Layers defined by composition

1. Crust

a. Thin, rocky outer layer

b. Varies in thickness

1. Roughly 7 km (5 miles) in oceanic regions

2. Continental crust averages 35-40 km (25 miles)

3. Exceeds 70 km (40 miles) in some mountainous regions

c. Two parts

1. Continental crust

a. Upper crust composed of granitic rocks

b. Lower crust is more akin to basalt

c. Average density is about 2.7 g/cm^3

d. Up to 4 billion years old

2. Oceanic crust
    a. Basaltic composition
    b. Density about 3.0 g/cm^3
    c. Younger (180 million years or less) than the continental crust
2. Mantle
    a. Below crust to a depth of 2900 kilometers (1800 miles)
    b. Composition of the uppermost mantle is the igneous rock peridotite (changes at greater depths)
3. Outer core
    a. Below mantle
    b. A sphere having a radius of 3486 km (2161 miles)
    c. Composed of an iron-nickel alloy
    d. Average density of nearly 11 g/cm^3

C. Layers defined by physical properties
1. Lithosphere
    a. Crust and uppermost mantle (about 100 km thick)
    b. Cool, rigid, solid
2. Asthenosphere
    a. Beneath the lithosphere
    b. Upper mantle
    c. To a depth of about 660 kilometers
    d. Soft, weak layer
    e. Easily deformed
3. Mesosphere (or lower mantle)
    a. 660-2900 km
    b. More rigid layer
    c. Rocks are very hot and capable of gradual flow
4. Outer core
    a. Liquid layer
    b. 2270 km (1410 miles) thick
    c. Convective flow of metallic iron within generates Earth's magnetic field
5. Inner core
    a. Sphere with a radius of 1216 km (754 miles)
    b. Behaves like a solid

D. Discovering Earth's major layers
1. Discovered using changes in seismic wave velocity
2. Mohorovicic discontinuity
    a. Velocity of seismic waves increases abruptly below 50 km of depth
    b. Separates crust from underlying mantle
3. Shadow zone
    a. Absence of P waves from about 105 degrees to 140 degrees around the globe from an earthquake
    b. Explained if Earth contained a core composed of materials unlike the overlying mantle
4. Inner core
    a. Discovered in 1936 by noting a new region of seismic reflection within the core
    b. Size was calculated in the 1960s using echos from seismic waves generated during underground nuclear tests

E. Discovering Earth's composition
1. Oceanic crust
    a. Prior to the 1960s scientists had only seismic evidence from which to determine the composition of oceanic crust
    b. Development of deep-sea drilling technology made the recovery of ocean

floor samples possible

2. Mantle
   a. Composition is more speculative
   b. Lava from the asthenosphere has a composition similar to that which results from the partial melting of a rock called peridotite
3. Core
   a. Evidence comes from meteorites
      1. Composition ranges from metallic meteorites made of iron and nickel to stony varieties composed of dense rock similar to peridotite
      2. Iron, and other dense metals, sank to Earth's interior during the planet's early history
   b. Earth's magnetic field supports the concept of a molten outer core
   c. Earth's overall density is also best explained by an iron core